ABSTRACT

Aim of the present work was to explore the possibility of improving strength of cast Mg by alloying additions, viz., Si and Zn+Al. All the alloys were produced by squeeze casting technique using squeeze pressure of 12 MPa and their microstructure, tensile and corrosion properties were studied.

Mg-Si system was chosen because the intermetallic compound Mg_2Si possesses many desirable properties, such as, low density, high hardness, high melting point. Hence, there is scope for improving the strength of Mg by dispersion of primary Mg_2Si particles. Addition of Si to Mg resulted in the formation of α-Mg, particles of primary Mg_2Si and eutectic as microstructural constituents. The morphology of primary Mg_2Si changed from polyhedral shaped particles to dendrites as Si content was increased from 3.57 to 5.5 wt%. Volume fraction of primary Mg_2Si increased with increase in Si content. Particle size of primary Mg_2Si also increased with increase in silicon content but at the same time it was found to be dependent on melt temperature, i.e., a lower particle size was obtained at higher melt temperatures. Addition of Al and Sr was made to Mg-2Si alloy in order to further increase the strength by solid solution strengthening and refinement/modification of primary Mg_2Si particles/eutectic. Addition of 1.2 wt% Al to Mg-2Si alloy resulted in irregular type of morphology of Mg_2Si particles and increased particle size. Addition of 0.2 wt% Sr to Mg-2Si-1.2Al alloy resulted in slight refinement of primary Mg_2Si particles and modification of eutectic. Addition of 0.4 wt% Sr resulted in both refinement and restoration of morphology of Mg_2Si particles from irregular to polyhedral shape. This was accompanied by destruction of eutectic, and rods containing Mg, Si, Al and Sr were observed.

The addition of 1.33 wt% Si to Mg resulted in improvement in 0.2%PS by about 80 MPa, UTS by about 40 MPa and these values did not change much till the addition of 3.57 wt% Si. A drop in the strength values was observed at Si content of 5.5 wt%, where transition in morphology of primary Mg_2Si occurred from polyhedral to dendrite. Addition of Si resulted in reduction in % elongation by about 2%. The

addition of Al and Sr did not change the tensile properties of binary Mg-2Si alloy much. It was concluded that the volume fraction and size of primary Mg_2Si particles obtained with Si addition up to 3.57 wt% did not contribute much to strength and the strengthening mainly came from the eutectic present in the matrix. As Si content was increased to 5.5 wt% in order to increase the volume fraction of primary Mg_2Si particles, the morphology of Mg_2Si changed to dendritic type resulting in reduction in strength. Thus, the maximum increase in strength is achieved at near eutectic composition, i.e., in the Mg-1.33Si alloy, and further increase in strength does not seem to be feasible with this alloy system. The ductility of all the Mg-Si based alloys was also low, i.e, 0.5% elongation to fracture or less. Regarding the corrosion behaviour, the addition of Si to Mg deteriorated the corrosion resistance and the addition of Al and Sr further worsened it.

Since further improvement in tensile properties did not seem feasible with Mg-Si alloy system, the focus was shifted to Mg-Zn-Al alloy system. There is scope for improvement in strength in Mg-Zn-Al alloy system by solid solution strengthening, grain refinement and precipitation hardening. It was observed that the addition of Zn and Al resulted in microstructure containing α-Mg grains and secondary phase at the grain boundary. XRD analysis showed the secondary phase to be $Al_5Mg_{11}Zn_4$ but EDS analysis did not match with this composition. Therefore, the nature of this phase remains uncertain. Addition of 6 wt% Zn and 1 wt% Al resulted in improvement in strength as well as ductility: 0.2%PS improved by about 70 MPa, UTS by about 100 MPa and % elongation by about 7%. Addition of small amounts of Ca resulted in refinement of microstructure causing improvement in strength without much decrease in % elongation. Increase in Al content from 1 to 4 wt% resulted in increase in 0.2%PS but UTS slightly decreased, as % elongation reduced. Alloys subjected to T6 heat treatment showed improvement in strength but slight reduction in % elongation. ZA64 alloy in T6 condition gave 130 MPa 0.2%PS, 225 MPa UTS and 4.9% elongation, which are much higher tensile properties as compared Mg-Si alloys. All the three mechanisms mentioned above contribute to the strengthening. There is scope for further improvement in strength by employing a more suitable heat treatment. Regarding corrosion behaviour, addition of 6 wt% Zn and 1 wt% of Al to Mg did not deteriorate its corrosion resistance much. Addition of small amounts of Ca was found to be beneficial for corrosion resistance, whereas an increase in Al content lowered the corrosion resistance. Heat treatment also reduced the corrosion resistance.